METHOD AND DEVICE FOR FORMING A PIPE

BACKGROUND OF THE INVENTION

【0001】 This invention relates to a method and a device for forming a pipe in which a plate with holes is formed into a completely circular pipe by means of a bending machine.

【0002】 A method of forming a completely circular pipe by bending a steel plate by use of a bending machine has heretofore been carried out with a bending machine in which one upper roll is vertically and horizontally movably arranged over two lower rolls arranged parallel. The pipe forming method disclosed in JP patent publication 63-36852 is one example. This prior method comprises a preparatory of bending a central portion, a main step and a step of bending both ends.

【0003】 In the preparatory step of bending the central portion, the upper roll is lowered offset relative to the two lower rolls to a position where frictional force necessary for the feed of the work is obtained. Thereafter, the upper roll is further lowered while pressing and bending the work for rolling until a predetermined arc necessary for the main step is obtained. After carrying out the main

step in which rolling is further carried out with the predetermined arc, the both end bending step is carried out in which pressing/bending is applied to both ends of the work.

【0004】 With this bending method, it is possible to bend a steel plate into a U-shape using part of its working steps. One example of such a method is proposed in JP patent publication 2000-288635. In this U-bending method, after moving a steel plate clamped between the upper roll and the two lower rolls to a predetermined forming start position, the upper roll is lowered with a lowering amount divided into a plurality of portions so as to form a predetermined arc, while rotating the lower rolls in normal and reverse directions at rotating amounts corresponding to the lowering amounts to carry out multiple step forming while gradually narrowing each forming toward the minimum curvature portion.

【0005】 The bending methods by use of the bending machines described in these two patent publications are used for flat plates in which no holes are formed. No mention is made about what influence the fact that holes are formed will have on the work accuracy if a hole is formed in the flat plate. If a pipe is actually formed by applying the bending method of JP patent publication 63-36852 to a work with holes, it

is known from experience that no normal bending is possible near the portions where there are the holes, and the radius of curvature partially decreases at such portions and the pipe is not made completely circular.

【0006】 Thus in forming a pipe with holes, in order to obtain a completely circular pipe, it has to be treated by one of the following two methods. That is, the pipe forming method of JP patent publication 63-36852 is applied without forming any hole in the work to form a completely circular pipe, and thereafter, holes are formed at predetermined positions by use of a drill. Otherwise, after a pipe has been formed by applying this pipe forming method to one in which holes have been formed in the work beforehand, bending is carried out again with a different kind of press means to correct the curvature of the pipe, which is out of true at the hole portions.

【0007】 But, simply by applying the pipe forming method of JP patent publication 63-36852, it is impossible to obtain a completely circular pipe. If holes are formed with a drill after forming a completely circular pipe, the pipe may become partially not completely circular due to the influence of drilling. If a material formed with holes is formed into a pipe, it may develop portions which are

partially not completely circular. Thus, it is necessary to carry out bending again at such portions. Thus, extremely complicated steps are needed. So it is difficult to obtain a completely circular pipe with a bending machine alone. A different kind of machine and step are needed for correction.

【0008】 An object of this invention is to provide a method and a device for accurately and efficiently forming a pipe with a bending machine only without using correcting means in uniformly bending a work with holes to a pipe diameter.

SUMMARY OF THE INVENTION

【0009】 According to this invention, there is provided a method of forming a pipe comprising the steps of feeding a work having a hole between an upper roll and a pair of lower rolls of a bending machine, the lower rolls being parallel to each other and relative to the upper roll, moving the work by the rotation of the lower rolls while supporting it with the upper and lower rolls, and forming a pipe by bending the work under pressure of the upper and lower rolls, wherein the forming comprises a rough forming step in which the work is formed into a pipe having a rough radius and a fine forming step followed by the

rough forming for finishing the pipe to a required radius, wherein in the rough forming step, the work is bent by pressing with the upper and lower rolls so that a required radius will be obtained at a hole portion, and in the fine forming step, no bending action is applied to the hole portion and the work is rolled by pressing with the upper and lower rolls so that at portion other than the hole portion, the radius will coincide with that at the hole portion.

【0010】 According to this invention, there is also provided a device for forming a pipe comprising an upper roll and a pair of lower rolls which are parallel to each other and are arranged so as to vertically oppose each other, one of the upper and lower rolls being provided so as to be movable vertically and horizontally relative to the other, actuators for rotating, raising and lowering the rolls so as to move while supporting a work with holes which is supplied between the upper and lower rolls by the rotation of the rolls, and simultaneously bend it under the pressure of the rolls to form a pipe, a control unit for controlling the actuators, the control including a control program for controlling a pipe forming step comprising a rough forming step in which the work is formed into a rough radius and a fine forming step followed by the rough forming step

for finishing it to a required radius, wherein in the rough forming step, the work is bent by pressing with the upper and lower rolls so that a required diameter will be obtained at the hole portions, and in the fine forming step, no bending action is applied to the hole portion, and the work is rolled by pressing with the upper and lower rolls so that portions other than the hole portions, the pipe radius coincides with that of the hole portions.

【0011】 With the method and device for forming a pipe, simply by operating a bending machine, without using any other auxiliary means or without needing troublesome auxiliary work, a finished product of a pipe can be formed by bending. In a method in which a pipe is formed by bending a work having holes, influences of pressing are different between the hole portions and other portions. Thus, in the rough forming step, bending is carried out such that the radius near the hole portions will be a required radius, which is the radius of the pipe of the finished product. The radius of the portions other than the hole portions is slightly larger than the required radius.

【0012】 Thus, in the fine forming step, rolling is carried out on portions other than the hole portions to apply bending so that the required diameter is

obtained. Since the hole portions are already worked to a required radius, by feeding the work with the upper roll separated from the work, or supporting it with the upper and lower rolls so that bending action is not applied, and thereafter by lowering the upper roller and continuing rolling, the radius of the portions other than the hole portions approaches the required radius, so that a pipe of a finished product is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

【0013】 Other features and objects of the present invention will become apparent from the following description made with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a control line with a perspective view of the bending machine embodying the present invention;

Fig. 2A is a view for explaining the rough pipe forming step;

Fig. 2B is a view for explaining the fine pipe forming step;

Figs. 3A, 3B and 3C are flowcharts of rough pipe forming step;

Figs. 3D and 3E are flowcharts of fine pipe

forming step;

Fig. 4 is an explanatory view of fine pipe forming step; and

Fig. 5 is a view showing holes of a work.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

【0014】 The embodiment of this invention will be described with reference to the drawings. Fig. 1 shows a perspective view of the bending machine of an embodiment with a block diagram of a control circuit for controlling driving units (or actuators). This bending machine has an upper roll 1 arranged between opposed frames F, and two lower rolls 2 and 2' provided below the upper roll 1 so as to be parallel to each other and relative to the upper roll 1. The upper roll 1 is provided so as to be moved up and down by a hydraulic cylinder 13 and to be movable back and forth by a motor 10.

【0015】 The lower rolls 2 and 2' are rotated in normal and reverse directions by a motor 6. While backup rolls and 2' are provided below the lower rolls 2, they are omitted for simplicity. A hydraulic cylinder 12 is provided to outwardly incline each frame F. In this embodiment, as the actuators, the motors 6, 10 and the hydraulic cylinders 12, 13 are

provided.

【0016】 The operation of the bending machine is controlled by a control circuit 5. It comprises a sequencer for carrying out control based on signals from a numerical setter 5s. A numerical setter 5a is for setting rotating amounts Z (Z1, Z2, ...) of the lower rolls 2, 2', which are converted to moving amounts of a work W. A numerical setter 5b is for setting vertical movement amounts Y (Y1, Y2, ...) of the upper roll 1, and a numerical setter 5c is for setting horizontal movement amount X of the upper roll 1.

【0017】 For these set values Z, Y and X, values set at the numerical setters 5a-5c based on bending parameters such as the yield point of the material, plate thickness, plate width, radius of curvature R and the size and position of the holes are input into the control circuit 5 beforehand. The numbers of revolutions of the lower rollers 2 and 2' are detected by signals from rotation sensors 7 and are converted to distance L in the control circuit 5.

【0018】 Vertical movement of the upper roll 1 is carried out by feeding hydraulic pressure to the hydraulic cylinder 13 by a hydraulic pressure control circuit 8. The amounts of its vertical movement are detected by a position detector 9 mounted on a side

frame F. The horizontal movement of the upper roll 1 is detected by a position detector 11 mounted on a lower frame. Operations of the motors 6 and 10 and the hydraulic cylinders 13 and 12 are controlled based on commands from the control circuit 5. Detected values of the position detectors 9 and 11 and the rotation sensors 7 are input to the control circuit 5.

【0019】 The method of forming a pipe by bending by means of this bending machine will be described below with reference to Figs. 2A and 2B and the flowcharts of Figs. 3A-3E. When a start button of the bending machine is pressed, the control circuit will begin control based on signals from an input device, selected beforehand from among control modes by an operator. In this control action, the operation conditions at the start are checked, and if there should be any abnormality, "abnormal message" is displayed.

【0020】 If there is no abnormality, it is determined that preparation for working has completed, and the actions shown in Fig. 2A and the subsequent figures will begin. First in step S1 of Fig. 3A, the backup rolls (not shown) are moved up or down, and in step S2 it is judged whether the backup rolls are at predetermined position H1. After a stopper 3 for the work W (steel plate) has been raised in step S3, as

shown in Fig. 2A (a), the work W is fed from the rear lower roll 2' toward the front lower roll 2 into between the upper roll 1 and the lower rolls 2, 2' and the work W is held with its front end abutting the stopper 3, which is arranged so as to be parallel to the lower rolls 2 and 2'. Also, before the start of operation, the upper roll 1 is at a standby position Y0 which is above the lower rolls 2, 2'.

【0021】 In response to the work feed end signal, the upper roll 1 is lowered to position YL (not shown) in step S5. In step S7, the upper roll 1 is moved from standby position X0 to position X1 toward the rear lower roll 2'. In S9, the upper roll 1 is lowered to set position Y1 to clamp the work W (see Fig. 2A (b)). In S11, the lower rolls 2, 2' are driven to move the work W so that the front end of the work W will come to a position right over the front lower roll 2 and spaced a distance Z1 from the stopper 3 (Fig. 2A (b)). The values X1, YL, Y1, Z1 are values calculated according to the bending mode beforehand and stored in the control circuit 5. The step automatically proceeds to the next operation after the work arrives at the set position.

【0022】 The below-described Y2, Y3 ..., Z2, Z3 ... etc. are also values calculated and set according to the bending mode. In the state of Fig. 2A (b), the

upper roll 1 is still set at position Y1 where the work W is retained in a horizontal state. In this position, no bending action is given to the work W. This completes the setting of the work W to the forming start position. After lowering the stopper 3 in S13, the lower rolls 2, 2' are driven in S14 to move the work W forward to start forming and feed it to set position Z2. Simultaneously with the start of forming, as shown in Fig. 2A (c), in S16, the upper roll 1 is lowered to set position Y2-θ. The work is subjected to bending under the pressing force by the upper roll.

【0023】 Driving of the lower rolls 2, 2' and lowering of the upper roll 1 are started substantially simultaneously. Y2 is a value necessary for keeping the upper roll 1 at set position in Fig. 2A (f). In the state of Fig. 2A (c), the upper roll 1 is set at set position Y2-θ which is just before the set position Y2.

【0024】 While the work W is being fed to set position Z2 in step S15, it takes time for the upper roll 1 to lower to set position Y2-θ. Bending during this time is in a spiral form because the position of the upper roll 1 changes little by little. By further bending after the upper roll 1 has lowered to set position Y2-θ, an R' portion is formed with the radius R'. But a

portion of a predetermined short length from the front end of the work W is left unworked. Thus, in S18, as shown in Fig. 2A (d), the upper roll 1 is lowered to set position Y3 (in S19) to carry out press end bending. Bending up to the length Z2 thus ends.

【0025】 Next, the entire circumferential length of the work W is formed into a pipe of a desired radius R (R>R') by reversing the feed direction of the work W as shown in Fig. 2A (e). First, from the state of Fig. 2A (d), in S22, while raising the upper roll 1 to set position Y2-α, the lower rolls 2, 2' are driven in step S20 in the opposite direction to set position γ. This is done to stabilize the work W on the lower rolls 2, 2' while the upper roll 1 is being moved to set position X2 in the below-described step S24.

【0026】 After raising the upper roll 1 to set position Y2-α, in step S24 shown in Fig. 3C, the upper roll 1 is moved in the opposite direction to set it in set position X2 as shown in Fig. 2A (e). After setting the upper roll 1 in the above position, the upper roll 1 is lowered in S26 to set position Y2, and the lower rolls 2, 2' are again driven in S28 in the opposite direction to feed it to set position Z3 (in S29).

【0027】 When the radius R' portion, spiral portion and straight portion pass, bending to a desired radius R is done by the upper roll 1 which is set at position

Y2 and the lower rolls 2, 2'. Further, in the same manner as in S18, press end bending is done for a portion of a predetermined short length from the opposite end by lowering the upper roll 1 to set position Y3 in S30. Thus, as shown in Fig. 2B (g), a pipe of the desired radius R is formed over the entire circumference of the work.

【0028】 This is a rough forming step carried out by bending the work W. This bending of the work W is working to a desired radius R. The radius R is slightly larger than the radius R0 of a pipe as the finished product to be ultimately obtained (R0<R). The reason is that as shown in Fig. 4, at portions near holes h of the work W, the influence of bending is stronger than at portions other than the portions near the holes, so that the radius will be smaller than at other portions and thus a pipe having a uniform radius will not result. Thus, work is done such that only the portion at the holes h will have the radius R0 of the finished product.

【0029】 In Figs. 2A (c) and 2A (f), which show the rough forming step, the reason why the vertical position of the upper roll 1 is set at (Y2-θ) and Y2 is as follows. As shown in Fig. 4A, while bending the work W during rolling in the going path, as described above, the straight portion, spiral portion and radius

R' portion are formed with the upper roll 1 set at Y2-θ, so that the radius of the portions near the holes will be R0' which is smaller than at other portions. As shown in Fig. 4B, bending is carried out with the position of the upper roll 1 set at Y2 in the rolling in the return path so that the radius at the hole portions will be the radius R0 of the finished product.

【0030】 In the rolling in the going and return paths, the contact points between the upper roll 1 and the lower rolls 2, 2' are T1, T2 and T3. The way the work W contacts the upper and lower rolls 1, 2, 2' remains unchanged until the work W reaches the state of Fig. 4B. But when the work W further moves in the direction of the arrow beyond the state of Fig. 4B, since the radius R0' at the hole portions h is different from the radius at the other portions, the way which they contact at T2 and T1 changes, so that slip occurs between the work W and the upper roll 1.

【0031】 In order to eliminate such a slip, the position of the upper roll 1 in the going path is set at Y2-θ, which is slightly above the position Y2 in the return path, so that the pressure by the upper roll 1 will be greater in the return path than in the going path, thereby smoothly rolling while preventing slip. Thus, by setting the position of the upper roll 1 at Y2 for the rolling in the return path, the

bending radius R0' of the portions at hole h in the going path will be the pipe radius R0 of the finished product, and the other portions will have a radius R which is slightly greater than R0.

【0032】 After the rough forming, as shown in Fig. 2B (h), the upper roll 1 is returned to the set position Y2-α and to the central position between the lower rolls 2, 2'. At this position, no load is applied on the work W. In order to return it to this set position, the upper roll 1 is raised in S34 to set position Y2-α, and the lower rolls 2, 2' are slightly driven in S32 to feed them to set position γ so that the work W will be in a stable state on the lower rolls 2, 2'. And in S36 in Fig. 3D, the upper roll 1 is returned to the central position.

【0033】 Next, in the fine forming step in Fig. 2B (i) and subsequent figures, bending is carried out so that the work will have the radius R0 as the pipe of the finished product. In S38, the lower rolls 2, 2' are driven to return the work W to a predetermined position, and in S40, the upper roll 1 is lowered to set position Y4. At this time, steps S40, S41 and steps S38, S39 are parallelly carried out. Thereafter in S42, the lower rolls 2, 2' are driven to feed the work W to set position Z4 (Z4-1 + Z4-2 + Z4-3), and the bending in the first fine forming step is carried

out. Thereafter,in the same manner, the lowering of the upper roll 1 and the feed of the work W by means of the lower rolls 2, 2' are repeated three times to move the work to Y5 in S44, to Z5 in S46, to Y6 in S48 and to Z6 in S50.

【0034】 Details about feed to set positions Y4, Y5 and Y6 and set position Z4, Z5 and Z6 are shown in Fig. 2B (i) and the flowchart of Fig. 3E. In S421, the lower rolls 2, 2' are driven to feed the work W to set position Z4-1. As shown in Fig. 2B (i), this position is a position just before the upper roll 1 reaches the holes h. At this set position, as shown in Fig. 2B (j), the upper roll 1 is raised in S422 to set position Y4-β, the lower rolls 2, 2' are driven in S423 to feed the work W to set position Z4-2. After passing the holes h, the upper roll 1 is lowered again to set it at position Y4. Thereafter, in S425, the lower rolls 2, 2' are driven to feed the work W to Z4-3 to carry out bending over the entire circumference. After carrying out the first fine forming in this manner, the work W is turned in the opposite direction to carry out the second fine forming with the upper roll 1 set at the position Y5. Next the work W is reversed to carry out the third fine forming with the upper roll 1 set at position Y6.

【0035】 While an example in which the fine forming is

carried out three times has been described, the number of fine formings may be more than or less than three. In any fine forming, the upper roll 1 is raised a little not to carry out bending near the holes h, and at any other portions the upper roll 1 is lowered little by little as the number of fine formings increases, to obtain the pipe radius R0 for the finished product. Also, the set position for fine forming and the number of risings and lowerings at the hole portions may be changed according to the number of holes.

【0036】 As shown in Fig. 5, if the work W has holes hL and hS having different diameters, handling should be made so that the hole HL, which is larger in diameter, corresponds to the above-described hole h because the influence of the hole hS, which is smaller in diameter, is smaller than that of the larger-diameter hole hL.

【0037】 As described above in detail, in the method and device for forming a pipe by bending a work having holes according to this invention, in the rough forming step, the hole portions are formed to a required radius while the other portions are formed to a slightly larger radius. In the fine forming step, pressing for bending is not done at the hole portions while the other portions are brought to a required

radius by rolling little by little. Thus, simply by operating a bending machine, the work can be finished to a finished product without the need of correcting work using other auxiliary means. Thus, a pipe can be formed accurately and efficiently by use of only a bending machine without troublesome work.